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Potential Multi-Project Baselines in the Power Sector in the Eastern Region of India

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Abstract

Both developed and developing countries have good reasons to be concerned about climate change. The United Nations Framework Convention on Climate Change (UNFCCC) aims to reduce emissions of greenhouse gases (GHGs) in order to "prevent dangerous anthropogenic interference with the climate system" and promote sustainable development (UNFCCC 1992). The Kyoto Protocol, which was adopted in 1997, aims to provide the means to achieve this objective and thus goes beyond mere calls for action. Under the UNFCCC, both the developed and developing countries agreed to take measures to limit emissions and promote adaptation to future climate change impacts, submit information on their national climate change programmes and inventories, and to promote technology transfer, awareness, training.

Several mechanisms have been proposed to achieve emissions reductions globally under the Kyoto Protocol. The Clean Development Mechanism (CDM) is one of three 'flexibility mechanisms' in the Protocol, the other two being Joint Implementation (JI) and Emissions Trading (ET). These mechanisms allow flexibility for Annex I Parties to achieve reductions by extra-territorial as well as domestic activities. The underlying concept is that trade and transfer of credits will allow emissions reductions at least cost. The CDM allows Annex I Parties to meet part of their emissions reductions targets by investing in developing countries. CDM projects must also meet the sustainable development objectives of the developing country. Further criteria are that Parties must participate voluntarily, that emissions reductions are "real, measurable and long-term", and that they are additional to those that would have occurred anyway. The last requirement makes it essential to define an accurate baseline.

This paper suggests and works out an approach to demonstrate the use of a multiproject baselines approach for the setting of standardized baselines for the electric power sector. It illustrates the use of this approach by applying it to the eastern regional power grid in India.

1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) aims to reduce emissions of greenhouse gases (GHGs) in order to "prevent dangerous anthropogenic interference with the climate system" and promote sustainable development (UNFCCC 1992). The Kyoto Protocol, which was adopted in 1997 aims to provide means to achieve this objective. The Clean Development Mechanism (CDM)[1] is one of three "flexibility mechanisms" in the Protocol, the other two being Joint Implementation (JI) and Emissions Trading (ET). These mechanisms allow flexibility for Annex I Parties[2] to achieve reductions by international as well as domestic activities. The underlying concept is that trade and transfer of credits will allow for emissions reductions at least cost. Since the atmosphere is a global, well-mixed system, it does not matter where emissions are reduced. The CDM allows Annex I Parties to meet part of their emissions reductions targets by investing in developing countries. CDM projects must also meet the sustainable development objectives of the developing country. Further criteria are that parties must participate voluntarily, that emissions reductions are "real, measurable and long-term", and that they are additional to those that would have occurred anyway. The last requirement makes it essential to define an accurate baseline to project what would have occurred in the absence of the project.

2. Baselines and Additionality

Reductions of greenhouse gas emissions must be additional to business-as-usual. If a project would have happened anyway, it should not be a CDM project and should not receive investment through that mechanism. Once a project has qualified for the CDM and been implemented, the Certified Emissions Reductions need to be calculated. To do so, the difference between the projected baseline and the project's performance needs to be calculated.

Like any projection, baselines depend on assumptions about the future. Key assumptions include the level of economic growth, energy supply and demand, and the emissions assumed as a starting point.

The possibility that the determination of additionality may be separated from the calculation of credits has been discussed in the climate negotiations. Additionality may be tested by use of various "additionality screens", including environmental, financial, investment and technological additionality (UNFCCC 2000). The methodology for calculating baselines to determine credits may be separate. The purpose of this paper is to consider the calculation of baselines, rather than dealing explicitly with additionality.

3. Minimising Transaction Costs While Ensuring Environmental Integrity

The aim of multi-project baselines is to seek a balance between ensuring environmental integrity and minimising transaction costs. Setting project-by-project baselines would increase the transaction costs of CDM projects and thus reduce the number of projects that attract investment. The experience of the AIJ[2] pilot phase was that baselines are time-consuming and highly subjective. Hence, there have been suggestions to standardise baselines across many projects, to set them for particular sectors or given technologies. Multi-project baselines based on emissions

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1 See Michael Grubb (1999) for a more detailed description of the CDM and its origin in the negotiations.

2 Activities Implemented Jointly. The AIJ pilot phase was initiated at the first Conference of the Parties to test the impact of implementing emissions reductions projects in some countries (developing countries or countries with economies in transition) and funded by others without generating credits.

intensity are known as benchmarks.[3] A concern about multi-project baselines is that they might undermine the environmental integrity, in that emission reductions might be credited that are not "real". The aim of this paper is to explore alternative options for multi-project baselines.[4]

Establishing a baseline for a particular activity, sector and/or region will potentially simplify the calculation of emissions reductions. Baselines need to be simple enough to be practical in developing countries. Various proposals for baselines are summarised in the Chairman's Draft Text on Mechanisms (26 October 2000) for the climate change negotiations. In bracketed text, it proposes that baselines for a CDM project should consider the lowest of:

a. "Existing actual emissions prior to the project;
b. The most reasonable economic technology for the activity;
c. Better-than-average current industry practice in the host country or an appropriate region; and
d. The [average] [top X per cent] for such an existing source in Parties included in Annex [I] [II]."
   (UNFCCC 2000, FCCC/SB/2000/Add.2: § 70)

While project-specific baselines may be costly, less stringent baselines pose a potential threat to the environmental integrity of the Protocol. If a multi-project baseline allows projects that would have occurred under business-as-usual, then free riders can claim credits for something that would have been created anyway. This threatens environmental integrity in that the project does not contribute to global emissions reductions. Under the CDM, both investor and host countries would have an incentive to inflate baseline emissions.

This paper considers a number of approaches to multi-project baselines for the electricity generation sector, and the implications for a set of hypothetical CDM projects in India.

4. Overview of the Power Sector in India

In India, primary energy production and consumption are dominated by coal. Tables 1 and 2 show this to be over 50%, with the remainder shared by nuclear, hydro, petroleum and natural gas.

Coal-based thermal generation dominates the electricity sector in India. Over the last 25 to 30 years, the capacity share of large hydro has declined, while that of nuclear power is growing slowly. The potential for hydro-power in India is 84,044 MW of which only 14.5% had been exploited by 1995. Hydro provided a substantial contribution in the 1970s but over time the balance has shifted to coal. The Indian power generation sector also includes a small amount of natural gas, hydro, nuclear, wind, solar, and biomass generation. India's ninth five-year plan (1997-2002) includes a target of 3,000 MW for non-hydro renewable capacity.

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3 See M. Lazarus *et al* (1999) for an evaluation of different approaches to benchmarking, and case studies of Argentina, China, South Africa, Thailand and the United States.

4 This paper does not analyse the difference between multi-project baselines and a project-specific approach, a topic that warrants further attention.

Table 1. Production of Primary Sources of Conventional Energy in India (Petajoules)

Year	Coal & lignite	Petroleum	Natural gas	Electricity hydro & nuclear	Total
1970-71	1598	286	56	996	2936
1980-81	2491	440	91	1784	4806
1990-91	4063	1383	693	2800	8939
1999-2000	5503	1340	1095	3381	11319

Table 2. Consumption of Primary Sources of Conventional Energy in India

Year	Raw coal (000' tonnes)	Crude petroleum * (000'tonnes)	Natural gas (million cubic metres)	Electricity ** (MWh)
1970-71	71230	18379	647	43724
1980-81	109310	25836	1522	82367
1990-91	213360	51772	12766	190357
1998-99	313476(r)	68538	25716	313839
1999-2000(p)	329047	85964	26872	N.A.

(P)-Provisional (r)- Revised
* Crude oil in terms of refinery crude throughout.
** Includes thermal, hydro & nuclear electricity in utilities.
Source: Central Statistical Organisation, 2000.

At present thermal plants account for 72.9% of the total power generation, while the hydro and nuclear power plants contribute 15.2% and 2.5 % respectively. India's energy/GDP ratio has declined over time (Dasgupta and Roy, 2000). The average age of the thermal power stations in India is 30 years. The abundance of coal (India's coal reserve is 2000 billion tonnes) coupled with short construction periods (3-4 years for the smaller plants with capacity below 250 MW and 6-7 years for plants above 250 MW) has encouraged dependency on thermal power. But in spite of that, the plant load factor (PLF)-an important indicator of operational efficiency, is very low in India (average is approximately 65%). Although over the years various measures have been taken to achieve higher PLFs, they compare poorly with international levels. The average PLF for the eastern (43.7%) and north- eastern (17.9%) region are much lower than the All- India level. Besides, the use of low quality coal reduces the efficiency of the thermal power plants. Thermal efficiency varies across plants due to differences in grades of coal used and vintages of the plants. The coal use factor ranges from 0.53 kg/kWh to 0.88 kg/kWh .

Table 3. Installed Generating Capacity of Electricity in Utilities and Non-Utilities in India (MW)

Year	Utilities				Non-utilities			Grand Total
	Thermal	Hydro	Nuclear	Total	Railways	Self generating industries	Total	
1970-71	7906	6383	420	14709	45	1517	1562	16271
1980-81	17563	11791	860	30214	60	3041	3102	33316
1990-91	45768	18753	1565	66086	111	8502	8613	74699
1999-2000(p)*	71341	23816	2680	97837	165	15835	16000	113837r

(p)- Provisional * - From 1995-96 onwards, Thermal includes wind also.
MW = megawatt = Thousands kilowatt.
Non-utilities include private power generation, some of which is sold to the grid

Table 4. Gross Generation of Electricity in Utilities and Non-Utilities in India (GWh)

Year	Utilities				Non-utilities			Grand Total
	Thermal	Hydro	Nuclear	Total	Railways	Self generating industries	Total	
1970-71	28162	25248	2418	55828	37	5347	5384	61212
1980-81	61301	46542	3001	110844	42	8374	8416	119260
1990-91	186547	71641	6141	264329	29	25082	25111	289440
1999-2000 (p)*	386776	80637	13267	480680	25	49975	50000	530680

(p)- Provisional
* - From 1995-96 onwards, Thermal includes wind also.
GWh = gigawatt hour = Million kilowatt hours.

The high dependency on coal implies that India's electricity industry has relatively high GHG (CO_2) emissions. In addition, some methane is released during coal mining, production of coal and natural gas as well. With 237 million metric tons of carbon released from the consumption and flaring of fossil fuels in 1997, India ranked fifth in the world behind the United States, China, Russia and Japan.[5] So it can be expected that high power generation in India to satisfy the growing demand for electricity will increase the CO_2 emissions several-fold. It is very much important to note that low PLF of the thermal plants, high T&D losses and other operational and technical inefficiencies make the Indian power industry unable to take full benefit from its existing generating capacity.

[5] http://www.eia.doe.gov/emeu/cabs/indiaenv.html

To improve the operation of current plants as well as to increase total capacity, the Union government has announced the following objectives for future development in the power sector (Planning Commission, 1997):

- Raise efficiency, generation, safety, and reliability and reduce pollution of all the power plants.
- Introduce new efficient technology in retiring plants with the aim of reviving them.
- Conduct energy audits to reduce primary as well as secondary fuel consumption (through better plant maintenance).
- Renovate and refurbish existing units
- Adopt new hydro projects.
- Formulate mega-power projects in both private and public sector, which supply power to more than one state. These projects will be supported by power purchase security through power trading corporations for generating power at the lowest possible cost.
- Encourage private sector investment.

5. Ownership Pattern of the Indian Power Sector

Transmission and distribution are dominated by the government either through public sector undertakings (PSUs) or State Electricity Boards (SEBs). Public sector undertakings are defined as public-private partnerships in which the government has more than 50% share. Very few private licensees are currently engaged in power generation and supply. In 1999, the Union government allowed private sector participation in power transmission and distribution. Now private enterprises can set up units either as licensees – distributing power to the licensed area from their own generation, or as generating companies – generating power to supply to the grids. At present more than 95.6% of the generating capacity is government owned and 4.4% is under the private sector. The following figure highlights the current structure of the electricity supply industry in India.

For integrated operation of the power system, the electricity distribution network in India is divided into several regions: North, West, South, East and Northeast. We focus on the Eastern region in this analysis. The Eastern region covers three states – West Bengal, Bihar and Orissa. Though public, private, and government-owned public sector undertakings (PSUs) are all engaged in power generation, transmission and distribution, the power industry in this region is dominated by the PSUs. Total installed capacity in this region is 16,973 MW which is 15% of the total installed capacity of the country. Six PSUs in this region own 57% of the total regional power-generation capacity. The public sector owns Calcutta Electric Supply Corporation (CESC), the only private licensee in this region, owns 29% and the remaining 14% of generation capacity. Like other regions, the regional power grid in the eastern region, governed by the Eastern Regional Electricity Board (EREB), facilitates flows of power from surplus to deficit areas and assists in the optimum utilization of the power available. Total consumption in this region in 1999-2000 was 46,165 megawatt hours (MWh). In 1998-1999, the Eastern region exported 3,628 MWh to the neighboring region, which was 40% higher than the previous year.

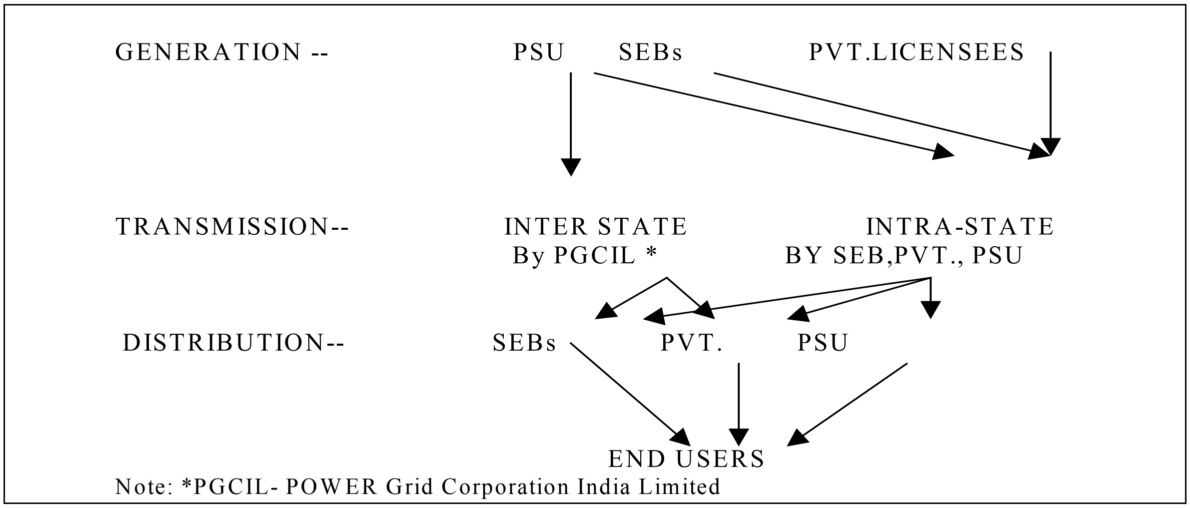

Figure 1. Current Structure of the Electricity Supply Industry in India

6. Characteristics of the Eastern Regional Grid Area

Regional electricity generating capacity is based on three primary resources: coal, oil, and hydro. The coal reserve of eastern region is the highest in India. The availability of coal encouraged the establishment of thermal power stations in this region at a greater rate. In spite of this, the Eastern region ranks fourth in thermal power generation among all regions in India. Although most of the thermal plants are owned and operated by PSUs (National Thermal Power Corporation, NTPC, Damodar Valley Corporation, DVC, GRIDCO) and SEBs (Bihar State Electricity Board, BSEB, West Bengal State Electricity Board, WBSEB), the CESC has a significant share in thermal power generation. These coal-based plants are mainly concentrated in West Bengal and Bihar, close to the major coal fields of the country.

In 2000, there were 25 thermal power plants with 44 major generating units in the Eastern region. Besides coal-based power stations, the Eastern region also has 15 hydroelectric power stations and four high speed diesel oil (HSDO)-based gas turbines.

The following table represents the current status of the installed capacity of conventional power stations of the Eastern region in 1999-2000.

Table 5. Installed Capacity in the Eastern Region, 1999-00

Type	Installed capacity (MW)	Capacity percentage
1.Coal Thermal	14211	84
2.Hydro	2567	15
3. Gas Turbine	195	1
Source: Eastern Regional Electricity Board (2000)		

The Eastern region electricity industry is highly dependent on thermal power plants. Capacity expansion in the Eastern region is continuing and a large expansion has been planned over the next decade covering the tenth and eleventh Five-Year Plan periods starting from 2003. Twenty-five units (including conventional and non conventional fuel based) with total capacity of 4,283 MW (25% of the total existing capacity) have begun operation since 1994. Of these, 81% are thermal with coal as the primary fuel source, 15% (about 650 MW) are hydro and the remainder (about 170 MW) are renewable sources such as solar and wind to meet the off-grid supply. These additions were financed by DVC, GRIDCO, WBSEB, CESC, NTPC, NHPC (National Hydro Power Corporation), and WBREDA (West Bengal Renewable Energy Development Agency). The future expansion plan of the next decade proposes to construct 26 power stations with a total capacity of 24,313 MW, details of which are given in Table 6.

Table 6. Future Capacity Addition Plans for the Eastern Region

Type	Capacity(MW)	Status	Ownership
Hydro	1067	expected by 2003-2004	Govt/PSU
Hydro	1220	expected by 10th plan	Govt/PSU
Hydro	4306	expected by 11th plan	Govt/PSU
Thermal	5450	expected by 10th plan	Govt/PSU
Thermal	2420	expected by 10th plan	Private
Thermal	7221	expected by 11th plan	Govt/PSU
Pump storage	900	expected by 10th plan	Govt/PSU

Source:EREB.

As in the other parts of the country, the Eastern region has a power deficit. Faster growth in power demand arising out of proposed industrial expansion and reduced use of petroleum products in rural areas contributes as well to this problem.

7. Baselines for Eastern Regional Grid in India

A key decision in determining baselines is to identify the plants to be included in the baseline. The potential CDM projects will be measured against the performance of these plants or units. Performance is measured in terms of carbon intensity (kgC/kWh). For any project to get credits through the CDM process, the "additionality" of the project must be determined. This necessitates knowledge of the baseline or "what would have happened anyway". Projects under the CDM get credit if they perform better than the baseline.

There are several issues which need to be resolved and which will have varying implications for the "additionality" and hence "carbon credit". Baseline may be constructed according to:

- Aggregate sectoral trend in past five-six years or decade
- Generation Fuel type: Coal based, Oil based, Hydro, Nuclear
- Ownership type, i.e., company based
- Project-specific performance

There are several advantages and disadvantages of each of these methods but if we take minimisation of transaction cost as the primary objective then a sector wide baseline that represents multiple projects may be the best alternative. The main focus of this work is to generate multi-project baselines for the Eastern region in India. Based on these multi-project baselines we estimate carbon credits that may be generated by several types of hypothetical CDM projects.

8. Recent Plant or Near Future

There are various alternatives for construction of multi-project baselines. One approach is to use data for recently constructed plants, assuming that these represent the best available technology. "Recent" may mean the past 3 to 5 years. An advantage of this approach is that the data for such plants is observable. A forward-looking baseline, which includes future plants, has the advantage that it can consider new, more efficient technologies. However, a forward-looking baseline needs to make additional assumptions about which plants would most likely be built in the future. Arguably it may be more "realistic" about what new technologies are likely to be used. The negotiating text defines a "reference scenario" as "a set of recent and comparable activities or facilities which are defined in a manner sufficient to demonstrate what would likely have occurred in the relevant sector in the absence of the proposed project activity" (UNFCCC 2000, § 60). The reference scenario can therefore be based on recently constructed plants or near future ones. The planned near future plants for the Eastern region (Table 6) will be using the same fuel source as plants constructed in the recent past except for the proposed pump storage facility.

9. Data and Methodology

The data essential for setting multiproject baseline are the fuel input (in GJ per year) and the electrical output (in TWh per year) of power plants. Combining this information with carbon content, we can calculate the carbon intensity. The carbon intensity is measured in mass of carbon per unit of energy produced, e.g. in units of kg CO_2/kWh. These data, if available at the lowest micro unit, yield the best result. For the Eastern region, we were able to collect the generation figures for each power plant unit . However, the fuel consumption data are based on average figures for the plant since unit-specific data were not available. Data have been collected from government publications at the regional offices of the Central Electricity Authority (CEA) and the West Bengal State Electricity Board. Plants have one or more units of differing vintages at the same site. Data are more readily available at the plant level, but analysis at this level may produce less stringent baselines if the plant includes many later vintage units, so we use the data collected from the monthly power generation and fuel consumption reports submitted by the individual units to the EREB. Coal factor and heat content data are India specific while carbon content data are the IPCC default values.

A second decision is to which set of plants to compare the potential CDM project. For example, does a new gas plant need to perform better than the average power station in the whole sector, the average fossil-fueled plant, or only better than other gas-fired plants? These comparisons can be applied to different sub-sets of the plants in the baseline. The project can be compared to other plants using the same fuel ("fuel-specific"), to all fossil fuel-fired plants ("all fossil"), or to the whole electricity generation ("sector-wide"). Obviously, the fuel-specific comparison is valid only if there is a plant or unit in the baseline using the same fuel as the project.

The third decision is whether to compare projects against average, better-than-average, or best plants. Once the carbon intensity of the plants in the reference scenario are known, we can construct increasingly stringent benchmarks – a "weighted average", "25th percentile", "10th percentile" or "best plant". One would expect the carbon intensity required by each of these benchmarks to be *lower* – in other words, the CDM project will have to show lower carbon intensity than a more stringent target. We report below the five scenarios that can be constructed as benchmarks for the Eastern regional power sector if power plants that have been built over last six years are used as the baseline.

10. Results

Table 7 shows the baseline intensities – both energy and carbon intensity – given the units included in the "recent past" baseline. No energy intensity is reported for the sector as a whole, since this concept has different meanings for fossil fuel plants and those using hydro and renewable energy sources. There is no "fuel" for hydro-power, so no fuel-specific intensities are reported. There are no plants, which use only one type of fuel. All thermal plants use coal and oil. Although coal-fired plants use coal as primary fuel, they do keep provision for use of oil as a supplementary fuel for two reasons: one for starting the system and second to supplement the primary fuel in case of supply shortage or technical fault and hence non-availability of the coal racks. Hence we cannot report any figures for coal-specific units. For hydro we assume that the carbon intensity is zero. Carbon intensity represents the baseline for CDM projects; energy intensity is reported for information only.

The benchmarks increase in stringency from left to right, as expected. The all-fossil energy and carbon intensity are identical whether one uses the "10^{th} percentile" or "best plant". This is because several of the coal units included in the baseline have identical performance. The zero carbon intensity for the sector-wide category reflects the inclusion of hydro and solar energy-based power-generation, which is zero-emitting. The baseline generally gets more stringent as one moves from all-fossil to sector-wide comparisons since the sector includes hydro and solar. The "best plant" benchmark will therefore always be zero whenever electricity is supplied by such plants.

Table 7. Energy and Carbon Intensities for the Recent Past Baseline

			Weighted Average	**Percentile 25%**	**Percentile 10%**	**Best Plant**
All Fossil	Energy intensity	MJ/kWh	13.84	9.39	8.43	8.43
	Carbon intensity	Kg C/kWh	0.345	0.241	0.217	0.217
Sector wide	Carbon intensity	Kg C/kWh	0.341	0.228	0.192	0.000

Source: authors' calculation.

11. Potential CDM Projects

The choice of potential CDM projects to include in the analysis is based on hypothetical examples. Since the purpose of this analysis is to investigate the impact of different baselines. However, to make the analysis worthwhile, realistic hypothetical cases have been selected. For this analysis, we choose four projects, keeping in view the plans in next decade in the Eastern region and including diverse projects – some using fossil fuels, others using hydro and renewable resources, as well as on-grid and off-grid projects:

- The Balagarh (500 MW capacity) and Maithon (1000 MW capacity) thermal power projects are planned under private and public sectors respectively. They have been planned to use better quality coal and less oil input, and should operate more efficiently than existing plants.
- Tala and Teesta are the large hydro projects of 1020 MW and 1710 MW capacity respectively

- A total of six MW of generating capacity under the renewable energy development agency has been planned for decentralised off-grid supply of power. Off-grid Solar Home Systems have been used to electrify rural areas unlikely to receive grid electricity. It is more likely that kerosene will be displaced for lighting. In comparing this programme to the multi-project baseline, one implicitly assumes that it will replace electricity.

This set of CDM projects in no way claims to be comprehensive[6]. We chose a small sample of projects that in our opinion are likely to provide enough information if any ground work for CDM projects is started at the policy level. Table 8 lists the projected performance data used to compare these five CDM projects to various baselines.

Table 8. Key Characteristics of Potential CDM Projects

	Tala	Teesta ST III & IV	Maithon Right Bank	Balagarh	Renewable
Capacity [MW]	1020	1710	1000	500	6
Annual generation [TWh]	4.468	7.490	6.132	3.504	0.006
Annual fuel use [GJ]					
Coal			52,241,574	29,852,328	
Oil			1,370,489	783,137	
Carbon intensity [kg C / kWh]	0.000	0.000	0.220	0.220	0.000

Sources: Developed from the Proposed Generation Plans available from EREB and WBREDA.

12. Decrease in Carbon Intensity from CDM Projects under Recent Past Baseline

Table 9 compares the performance of projects against different baselines. It shows by how much the CDM project's intensity was lower than the baseline. A positive number indicates a lower carbon intensity than the baseline. The larger the number, the better the performance in terms of carbon intensity. Positive numbers show viable CDM projects.

Results suggest that:

- Carbon savings generated from fossil fuel based CDM projects, Maithon and Balagar, decline as one moves from the "all fossil" to the "sector-wide" baseline, since the latter includes hydro and renewables. Using the the fossil-fuel based plants are considered we find that the two thermal projects perform worse than the "best plant" and "10 percentile" plants. With a sector-wide comparison, thermal projects would be less likely to attract CDM investment with stringent baselines.
- Renewables and hydro projects do well under all scenarios. To determine eligibility, renewables in India should be compared to the sector-wide values, since they might substitute a wide range of electricity sources, not only coal.
- In a coal-dominated energy economy, the benefit of moving to hydro and renewables are significant.

[6] Projects that are *not* included in the analysis are the nuclear, gas, imported coal due to the uncertainty whether nuclear technologies can be accepted as CDM projects, and how far the other types will be installed in the region.

- The additional credits from a less stringent baseline can be quite substantial, as shown in the annual emissions reductions in kilotonne of carbon in Table 10. The results reflect the different sizes of projects, as well as their carbon intensities.
- The relatively small absolute carbon reductions for off-grid solar projects are primarily due to the small size of the project (6 MW).
- If better-than-average benchmarks (e.g., "10th percentile") are applied, the fossil-fuel CDM projects result in relatively small or no carbon reduction for their size.

Table 9. Reduction in Carbon Intensity Baseline [kg C/kWh] from CDM Projects Relative to Recent Past

	Baseline standard	Tala	Teesta ST III & IV	Maithon Right Bank	Balagarh	Renewable
All fossil	Weighted average	0.345	0.345	0.126	0.126	0.345
	25th percentile	0.241	0.241	0.021	0.021	0.241
	10th percentile	0.217	0.217	-0.003	-0.003	0.217
	Best plant	0.217	0.217	-0.003	-0.003	0.217
Sector wide	Weighted average	0.341	0.341	0.122	0.122	0.341
	25th percentile	0.228	0.228	0.008	0.008	0.228
	10th percentile	0.192	0.192	-0.027	-0.027	0.192
	Best plant	0.000	0.000	-0.220	-0.220	0.000

Source: author's estimates.

Table 10. Carbon Reductions by Project Based on Recent Past Baseline [Thous. t C/yr]

	Baseline standard	Tala	Teesta	Maithon	Balagarh	Solar
All fossil	Weighted average	1,543	2,587	770	440	2
	25th percentile	1,076	1,803	129	73	1
	10th percentile	967	1,622	none	none	1
	Best plant	967	1,622	none	none	1
Sector wide	Weighted average	1,526	2,558	746	426	2
	25th percentile	1,016	1,704	47	27	1
	10th percentile	859	1,441	none	none	1
	Best plant	none	none	none	none	none

Source: authors' estimates.

13. Concluding Remarks

This analysis provides some useful guidelines for future choice of power projects in the Eastern region if carbon intensity reduction is the objective. Given that demand for power will be on the rise, and taking into account unmet demand, it is very likely that low-gestation period coal based thermal plants will be on the priority list. In such a scenario, the increasing damage to the environment can be mitigated through increased efficiency and use of low carbon fuels. An extremely pertinent issue is how do we look at the CDM projects: as a source of investment in more expensive projects or as means to address both investment source and environmental objective? Given the recent past experience, any efficient thermal plant can earn credit compared to the baseline if less than 'best plant' scenario is considered. If the current rate of subsidy given for establishment of renewable power plants is considered then the argument in favor of commercial adoption of these investments may be questioned. These issues become more relevant once the institutional changes in terms of liberalisation and invitation for private investment in power sector are considered. Given that the public sector would still continue to hold a very important position in the power sector, investment in new power projects may be monitored through these sector-wide baseline estimates.

Another primary question in terms of the CDM is can we consider the thermal, hydro and renewables as "additional" in the Eastern region of India? Past and near future plans may confirm that they are happening anyway in this region for commercial reasons. In that sense maybe gas based power plants and nuclear are the only candidates for the CDM. It is hard to solve this issue given the scope of this study. The present study does not address the full question of additionality as it is focused at estimation of baseline only. More accurate baselines could be established in future studies if the following could be accomplished:

- Improving data quality, e.g., actual coal consumption per power unit in the power stations rather than average consumption reported.
- Using the plant specific calorific value and carbon content of the coal used.
- Estimation of other power plant types from other regional grids, e.g., gas-based and nuclear plants to establish sector-wide as well as country-wide baselines.
- Making the baselines adjustable.
- Calculating baseline for privately- and publicly-owned plants separately since the latter sometimes do not follow commercial principles.

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